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Lignin depolymerization in basic-subcritical water over Mo/SBA-15 catalyst into phenolic monomers

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In recent years, the research interests in biomass conversion to high value-added chemicals and fuels have drawn much attention in view of current problems such as high oil prices, food crisis, global warming, and other geopolitical scenarios. In this report, an SBA-15 supported molybdenum catalyst (Mo/SBA-15) was explored for the depolymerization of kraft lignin in hydrothermal liquefaction process. Experiments were carried out at 300°C in a batch reactor under the N_2 atmosphere at two different solvents (H_2O and 0.5% NaOH) system. The catalysts were characterized by XPS (X-ray photoelectron spectroscopy), HR-TEM (High-resolution transmission electron microscopy)and BET (Brunauer-Emmett-Teller) experiments analysis. Incorporation of molybdenum has increased the average pore sizes (from 5.74 to 5.82 nm) into SBA-15 which was confirmed by BET experiment analysis. XPS results revealed that spinel structures are detectable after the thermal treatment of Mo/SBA-15, which could be attributed mainly to the Mo_3O_4 formation. The highest crude bio-oil yield (46 wt.% oil yield) and lowest gas formation were observed in subcritical water condition than 0.5% NaOH (44 wt. % oil yield) system with 10 wt.% synthesized catalyst loading. The GC-MS analysis of the produced bio-oil shows that the major products in crude bio-oil were phenolic type monomers such as guaiacols (40.99% peak area), catechols (36.45% peak area) and traces of nitrogenized compounds in subcritical water. Alternatively, catechols (77.90 % peak area) were the main product in the basic solvent system. This is might be due to demethylation of guaiacols to low molecular weight phenolic monomers like catechol. Phenols (5 % peak area) were also produced as a result of the hydrogenation reaction of either guaiacols or catechols. The effective delignification nature associated with Mo/SBA-15 catalyst resulted in significant reduction in the oxygen-carbon ratio (O/C) from 0.32 to 0.29 in basic subcritical water. The decrease in oxygen content and increase in carbon and hydrogen contents increased the calorific value of the produced bio-oil, with higher heating value (HHV) of 32.09 MJ/Kg.

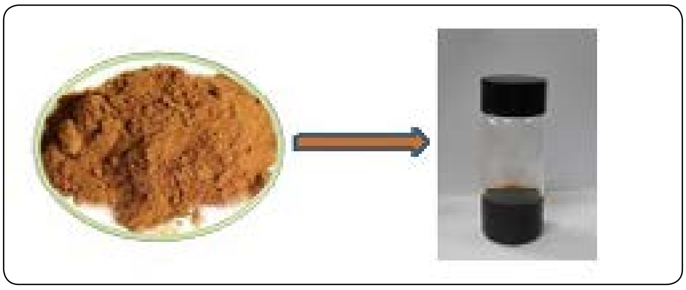

Figure 1: Lignin depolymerization in basic subcritical water over Mo/SBA-15.

Recent Publications:

1. Javier F R et al. (2017) Lignin depolymerization for phenolic monomers production by sustainable processes. Journal of Energy Chemistry. 26(4):622-631.
2. Riyang S et al. (2018) Controllable production of guaiacols and phenols from lignin depolymerization using Pd/C catalyst cooperated with metal chloride. Chemical Engineering Journal. 338:457-464.
3. Jaeyong P et al. (2018) Understanding the relationship between the structure and depolymerization behavior of lignin. Fuel. 217:202-210.
4. Bjarte H et al. (2017) Production of monomeric phenols by formic acid assisted hydrous liquefaction of lignin. Biomass and Bioenergy. 105:298-309.
5. Jindong W et al. (2017) Liquefaction of kraft lignin by hydrocracking with simultaneous use of a novel dual acid-base catalyst and a hydrogenation catalyst. Bioresource Technology 243:100-106.

Biography

Md. Masud Rana, studying PhD program in the Department of Environment and Energy Engineering at Chonnam National University, Gwangju, South Korea. Before joining at CNU, he graduated from the University of Rajshahi, Bangladesh. In that time period, he worked on catalytic chemistry. Now, his ongoing research focuses on bio-oil production from lignocellulosic biomass and also upgrading the bio-oil using green technologies.

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